THIRTY-NINTH ANNUAL REPORT

FOR 1919-20

OHIO
Agricultural Experiment Station

WOOSTER, OHIO, U. S. A., JUNE, 1920

BULLETIN 346

The Bulletins of this Station are sent free to all residents of the State who request them. When a change of address is desired, both the old and the new address should be given. All correspondence should be addressed to EXPERIMENT STATION, Wooster, Ohio.

Thirty-Ninth Annual Report

OF THE

Ohio Agricultural Experiment Station

For the Year ended June 30, 1920

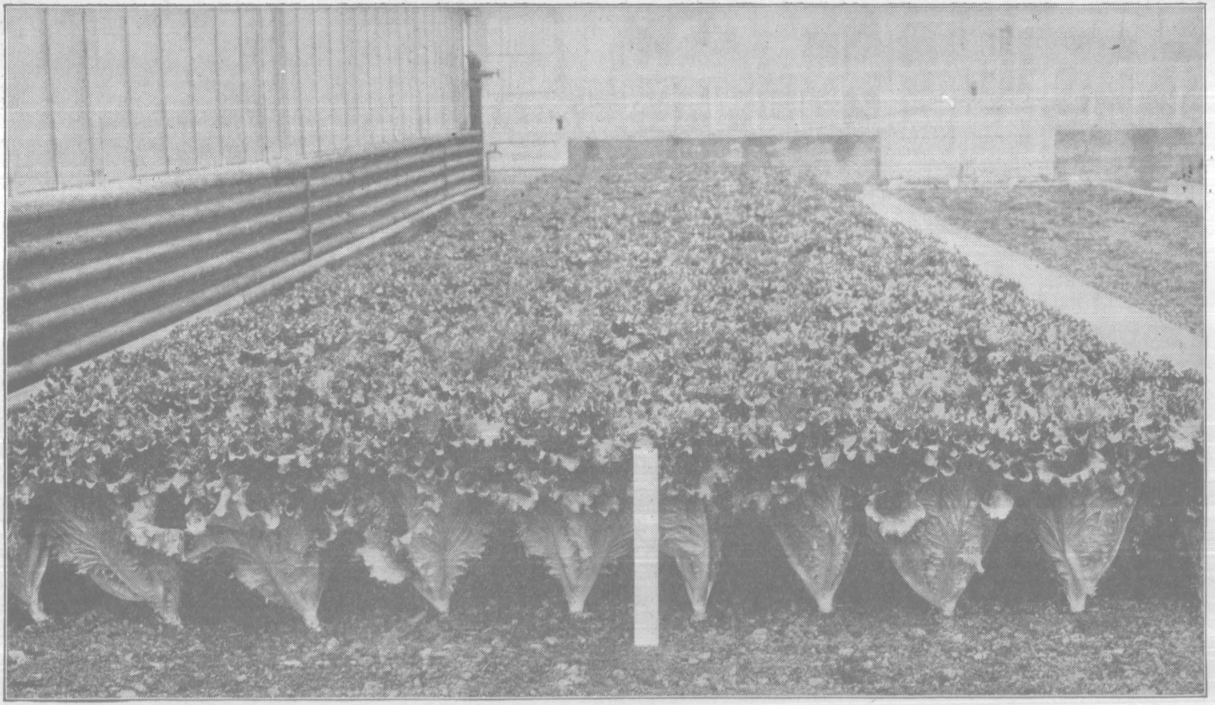
Published by the order of the State Legislature

WOOSTER, OHIO
EXPERIMENT STATION PRESS
1920

HON. JAMES M. COX,
Governor of Ohio:

SIR: I have the honor to transmit herewith the Thirty-Ninth Annual Report of the Ohio Agricultural Experiment Station, for the year ended June 30, 1920.

G. E. JOBE,
President of the Board of Control



Dark strain of Grand Rapids lettuce developed at the Ohio Experiment Station

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RUTH E. MCCOY ..... Office Assistant
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FIRMAN E. BEAR, Ph. D.[1] ..... Associate (Columbus)

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B. S. DAVISSON, A. M., *Assistant* ..... Soil Biology
G. W. CONREY, A. M., *Assistant*[1] ..... Soil Survey (Columbus)
A. BONAZZI, B. Agr., *Assistant* ..... Soil Biology

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Southeastern Test Farm, Carpenter
S. C. HARTMAN, M. S., *Superintendent*

Southwestern Test Farm, Germantown
HENRY M. WACHTER, *Superintendent*

Northwestern Test Farm, Findlay
JOHN A. SUTTON, *Superintendent*

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Paulding Co. Experiment Farm, Paulding
H. R. HOYT, *Supt.*, Wooster

Clermont Co. Experiment Farm, Owensville

Hamilton Co. Experiment Farm, Mt. Healthy
H. W. ROGERS, *Supt.*, Mt. Healthy

Washington Co. Experiment Farm, Fleming

Washington Co. Truck Experiment Farm, Marietta
S. C. HARTMAN, M. S., *Supt.*, Marietta

Mahoning Co. Experiment Farm, Canfield

Trumbull Co. Experiment Farm, Cortland
J. PAUL MARKLEY, *Supt.*, Canfield

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C. W. MONTGOMERY, *Acting Supt.*, Wooster

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Waterloo State Forest, New Marshfield
JOHN WITHERS, *In Charge*

Dean State Forest, Steece
G. C. MARTIN, *In Charge*

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[1]In cooperation with College of Agriculture, Ohio State University.
[2]In cooperation with the U. S. Department of Agriculture.
[3]On leave of absence.

ANNOUNCEMENT

The Ohio Agricultural Experiment Station is organized under an act of the General Assembly of Ohio, passed April 17, 1882, and supplemented by an act of Congress, approved March 2, 1887.

WHAT THE STATION CAN DO

The Station offers its advice and assistance to the farmers of Ohio along the following lines:

The maintenance of soil fertility, including the rotation of crops and the selection and use of manures and fertilizing materials.

The selection of varieties of grains, grasses and forage crops and methods of culture.

The selection of varieties of fruits and vegetables and the management of orchards.

The examination of seeds that are suspected of being unsound or adulterated; the identification of grasses, weeds and other plants; the prevention of fungous diseases of plants.

The identification of insects and the control of such as are injurious.

The feeding of animals, including calculation of rations and use of various feeding stuffs.

The planting and care of forest trees and the management of farm woodlots.

Visitors to the Station or its various test farms are welcome at all times during business hours. Persons or parties who contemplate such visits and who desire special attention are requested to write in advance, giving date of proposed visit and probable number of party.

Any citizen of Ohio has the right to apply to the Station for such assistance as it can give, and all such requests will receive prompt attention.

The bulletins of this Station are sent free to all residents of the State who request them.

WHAT THE STATION CANNOT DO

For advice and assistance along the following lines, application should be made to the Ohio State Board of Agriculture, Columbus, not to the Experiment Station.

The analysis of commercial fertilizers, of lime or limestone for agricultural purposes, and of feeding stuffs.

The treatment of contagious diseases of animals.

The inspection of orchards and nurseries for the control of San Jose scale.

The examination of foods, drugs, and dairy products suspected of being adulterated.

The Station is not prepared to analyze drinking water; requests for such analysis should be addressed to the Secretary of the State Board of Health, Columbus.

Address all communications to

Experiment Station,

Wooster, Ohio.

REPORT OF THE DIRECTOR

HON. G. E. JOBE,

President of the Board of Control.

Sir: I have the honor to present herewith the thirty-ninth annual report of the Ohio Agricultural Experiment Station.

METHOD OF WORK

From its earliest conception, scientific research in agriculture has been actuated by two different motives, the one concerned chiefly or altogether with the discovery, through the aid of the chemist's and biologist's laboratories, of new territories in the realm of knowledge, the other with the subjugation of those territories to the farmer's occupation and use.

The great German chemist and teacher, Liebig, seems to have seen little outside of laboratory walls, but his contemporaries, Boussingault in France and especially Lawes and Gilbert in England, themselves practical farmers, made the open field their chief laboratory, using the equipment and methods of chemical and biological research merely as adjuncts to the work of the field.

The first state-controlled experiment stations in America were established in Connecticut in 1875, in North Carolina in 1877, in New Jersey in 1880 and in New York, Ohio, and Massachusetts in 1882. All of these stations, except those of New York and Ohio, were devoted chiefly to the analysis of feeding stuffs and fertilizers, and were directed from the chemist's laboratory.

In Ohio, fortunately, the fertilizer control had already been lodged with the secretary of the State Board of Agriculture, thus leaving the Experiment Station free to devote its entire energies to research, and the act of the state legislature establishing the Ohio Agricultural Experiment Station, passed April 17, 1882, declares that this Station is established "for the benefit of the interests of practical and scientific agriculture, and for the development of the vast agricultural resources of the State." This function of the Station has never been lost sight of in the various amendments to the law, but is emphasized in the present law, which provides that the members of the governing board of the Station shall be practical farmers.

From the beginning, therefore, and throughout the history of this Station, it has been the evident intention of the law that immediate helpfulness to the practical Ohio farmer in the management of his farm should be the first consideration in the conduct of the Station's work.

REMOVAL OF THE STATION

It was very soon discovered that, if the work of the Ohio Station was to be made a safe guide to the average Ohio farmer, it must not only be carried over a long period of years, but must also be conducted on a different type of soil from the fertile bottom and terrace lands belonging to the Ohio State University, upon which the Station was first located; but the rapid growth of the city around the University showed that no expectation could be entertained of permanency in any work undertaken on that farm, even if the land had been suitable, and for these reasons, in 1891 the Station was authorized by the legislature, by a practically unanimous vote, to seek a new home.

The experience gained in its first 10 years' work made it possible to relocate the Station on land and under conditions most favorable to the object in view; but this relocation involved a new beginning with the larger part of its work. Land must be drained, buildings erected, orchards planted and herds of livestock established.

Field experiment at the best is tedious work. A whole season is required for the growth of a crop, and when several crops are grown in rotation, as they are in any good farming practice, it will be at least as many years as there are crops in the rotation before any but the most superficial estimates can be made of the outcome; while seasonal variations are so great that more than one rotation is required to justify definite conclusions.

It was therefore not until the opening years of the new century that the Station was able to offer advice, with respect to many of the fundamental problems of the farm, that was based upon sufficient data to be satisfactory even to the farmers in Wayne County and vicinity, while those whose soil and climatic conditions differed materially from those of the region in which the Staton is located received such advice very doubtfully.

EXTENSION OF WORK

In 1894, it is true, work had been started upon the Strongsville farm, and on sandy land in Fulton County, but these types of soil represent relatively small areas.

In 1903 the work was extended to southeastern and southwestern Ohio, by the establishment of experiment farms at Carpenter, Meigs County, and at Germantown, Montgomery County. In 1909 work was begun in a small way at Findlay, Hancock County, and during the years 1910 to 1917 county experiment farms were established in nine counties, widely scattered over the State.

In 1912 the work was reinforced and tied together by a reconnaissance soil survey of the entire State, by which the different soil formations were approximately delimited.

During this last decade, therefore, the Station has been enabled to bring under scientific observation and experiment all the principal soil types of the State, and to conduct its investigations in the light of the broad experience gained not only in its own work but in that of the similar stations located in surrounding states, several of which have adopted the same methods of extension through outlying experiment farms and soil surveys as those practiced in Ohio.

The outcome of this work is that the farmers of these states are now in position to conduct their business in the light of a more definite information respecting the possibilities and limitations of soil and crop than has ever before been available to any farmer in all the world.

INCREASING CROP YIELDS

And farmers are making use of this information. The statistics of crop production in Ohio, as collected by the township assessors, show that the average yields of the principal crops in the State have been as shown below for the seven 10-year periods since the collection of such statistics was begun:

AVERAGE YIELD IN BUSHELS PER ACRE BY 10-YEAR PERIODS

	1850–9	1860–9	1870–9	1880–9	1890–9	1900–9	1910–19
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Corn	33.1	32.2	36.9	33.9	34.3	36.6	37.7
Wheat	12.2	11.2	13.3	13.7	14.6	14.6	17.3
Oats	17.9	25.6	27.7	30.4	29.1	31.9	38.3

These statistics show that the decade of the 'seventies was one of higher yields than had previously prevailed. Towards the close of this decade the use of commercial fertilizers began, these fertilizers being applied chiefly to the wheat crop, and that crop shows slowly increasing yields for the next 30 years, with a marked gain for the period following. Corn and oats have gained rapidly for 20 years and the yield of all these crops has averaged greater for the decade 1910-1919 than for any preceding period.

Compared with the yields during the 'seventies, there has been an increase of eight-tenths of a bushel per acre in the average yield of corn; of 4 bushels in that of wheat and of 10.6 bushels in that of oats, or a total yield of more than 2,200,000 bushels of corn, 7,000,000 bushels of wheat and 14,000,000 bushels of oats more than would have been produced on the areas given to these crops during the last decade, had the rate of yield remained at the level of the 'seventies. At prewar prices of approximately 50 cents a bushel for corn, $1 for wheat and 40 cents for oats, there has been a total increase in the value of these crops for the State amounting to an average of $14,000,000 annually, to produce which there has been an annual expenditure of $5,000,000 in commercial fertilizers.

The object lessons offered by the fields of the Experiment Station, scattered over the State as they are, have been a potent factor in encouraging this larger use of fertilizers, and they have also led to a more economical use of such fertilizers and to a more careful saving and more effective use of farm manures, 12,000,000 loads of which are reported by the township assessors as having been distributed over the crops grown in 1918.

IMPROVEMENT OF THE CEREALS

From its first establishment the Station has grown a large number of varieties of the cereal grains in comparative tests, which have been extended to the outlying farms, the results of which comparisons have enabled the farmers of the State to select the more productive varieties. During more recent years this work has taken the form of scientific selective breeding, by means of which a few of the standard varieties, that had demonstrated superior qualities in the previous long-time tests, have been still further improved, and these sorts are being quite generally distributed over the State. By means of this work very decided improvement is being made, not only in the yield of grain but in stiffness of straw in the small grains.

CONTROL OF PLANT DISEASES

The effect of fungicidal sprays in the control of plant diseases was discovered in the early 'eighties, and experiments with such sprays were immediately undertaken by the Ohio Station. This Station was one of the first to use a combined spray for both insect and plant disease control. Its work was extended from year to year and formed the basis for the law providing for the official inspection of orchards and nurseries, enacted in April, 1900.

At first the execution of this law was lodged with the Experiment Station, but at a later date it was transferred to the Department of Agriculture, in harmony with a growing conviction that most forms of executive or police work relating to agriculture should be centralized in that department, leaving the Experiment Station free to concentrate its energies on research.

ORCHARD INVESTIGATIONS

The work which led to the organization of orchard and nursery inspection was by no means finished with the transfer of that function to the Department of Agriculture, but investigations relating to the general care of the orchard, but which do not come within the limits of public control, have continued to be as necessary as before this transfer was made.

In pioneer days the apple orchards of southeastern Ohio were a very important source of revenue, the river furnishing a cheap and convenient highway over which the fruit was transported by flatboat to southern markets; but within the last quarter of the past century the yield of apples had fallen to so low a point, and the fruit was of such inferior quality, that orchard owners were beginning to cut down their trees.

An investigation, made on the ground by this Station in 1909, showed that not only were the orchards seriously infested with insects and with scab and other diseases, but that the trees were literally starving to death.

A few representative orchards were selected for experiments both in insect and disease control and in fertilization, with results which immediately demonstrated the practicability of restoring these orchards to abundant and profitable fruitfulness.

Of course it is impossible to secure the immediate adoption by all farmers of an improved practice in agriculture, and it is especially difficult to accomplish such improvement in a region in which a long period of soil deterioration has very greatly reduced the farmer's capital, but enough orchard owners in Washington County have profited by the work done in a few orchards in their midst to halt the downward trend of apple production in that county and start it upward, as shown by the following annual yields of apples by periods, as compiled from the statistics collected by the township assessors:

Average annual production of apples in Washington County, Ohio:

Period	Bushels
1870-1879	248,916
1880-1889	374,193
1890-1899	168,662
1900-1909	90,980
1910-1918	256,841

The work done in Washington County has also influenced the care of orchards in the surrounding counties, and the total annual production of Washington and the four contiguous counties has been 300,000 bushels greater during the last decade than during the previous ones.

INVESTIGATION OF ANIMAL DISEASES

The work of the former Livestock Commission was laid upon the Experiment Station in 1900, but this also was transferred to the Department of Agriculture, for the reason given before.

This distinction between research and control is one not always readily understood or easy to carry out. The Experiment Station began the study of bovine tuberculosis in Ohio in 1897, and should have continued that study, as well as that of other animal diseases, but at this time the legislature was not ready to make adequate provision for such work.

The experimental study of the causes, prevention and cure of animal disease is one of the most important lines of research in agriculture that can be undertaken; it is fundamental to successful teaching on the one hand and to successful control on the other, and neither teaching nor control will ever reach the plane they should occupy until adequate provision is made for this work; but such provision cannot be made until the investigator is released from the exacting demands of the class room on the one hand and the execution of law on the other.

A common misapprehension exists in the public mind that it is a duplication of work to teach, to execute, and to investigate under the same general subject, and that the same person can conduct all three lines of effort at the same time and accomplish every day a full day's work in each. It would be just as rational to expect a man to do a full day's work in each of the old trades of blacksmithing, carpentry and shoemaking every 24 hours. And more than this, the old adage concerning the jack of all trades applies to mental quite as forcibly as to mechanical pursuits.

It is true that the three lines of work impinge upon each other, and that each worker needs help that the other should give, but this does not mean that they must work under the same roof, in this day of rapid and easy communication.

The statistics collected by the township assessors show that the annual losses from animal diseases in Ohio amount to more than $3,000,000. This loss is of course not all preventable, but it would seem worth while to invest 1 or 2 percent of this amount in the attempt to discover better methods of prevention than we now know.

The work of this Station during the last 20 years has demonstrated both the practicability and the economy of controlling tuberculosis in cattle. That disease is still taking its toll from Ohio herds, but the method for its control is now known, and the farmers of the State are slowly becoming convinced that the remedy lies in their hands.

Contagious abortion in cattle today presents a more difficult problem than tuberculosis, because its causes and methods of prevention are not so well understood. There is a field of work here that should be immediately occupied by this Station.

ANIMAL NUTRITION

The experiments of this Station in the maintenance of soil fertility showed, at an early date, that the soils of Ohio were becoming deficient in the mineral elements, phosphorus and calcium, which form the basis of the skeleton, a deficiency logically consequent upon the prevalent system of agriculture, and in 1907 a line of investigation was undertaken, having for its object the study of the possible effect of such deficiency in the soil upon the crops grown upon it and upon the animals fed upon those crops.

The outcome of this work has demonstrated that soil deficiency is reflected in the crop, and that food deficiency is reflected in the skeleton, as suspected.

This work has shown that during lactation the skeleton of the cow is drawn upon to keep up the supply of the mineral elements in the milk, and that the skeleton of the growing animal is so largely influenced by its food that slight errors in feeding may lead to serious loss.

Under natural conditions the vegetation on the land grows to maturity and returns to the soil again, restoring all the mineral elements that it has withdrawn, together with increments of nitrogen that the leguminous plants have obtained from the atmosphere, and the soil gradually becomes more productive.

Under such conditions, also, the animal life of the forest and prairie find all that is required for their maintenance, and leave it again on the soil.

But man, even in his primitive agriculture, upsets this balance by moving crops and animals away from the soil which had nourished them, while, as his processes become more and more complex this natural balance is still further disturbed.

As an extreme illustration, sugar and fat are very important constituents of the dietary, but the animal or person limited to these alone will soon perish of starvation.

In view, therefore, of the increasing complexity of our methods of agriculture, and of the constantly increasing number of by-products that are coming into use in the dietaries both of animals and men, this study of the function of the mineral elements in the nutrition of the animal organism, using the term animal in its comprehensive sense, must take rank scarcely second to that of the maintenance of the fertility of the soil.

The common feeding experiment, in which different rations are contrasted on the basis of their relative proportions of protein, carbohydrates and fat, has served a very useful purpose. It was the necessary first step forward, but the time has come when we must go deeper into the problems of nutrition, under the guidance of more elaborate research than has heretofore been undertaken.

STATE FORESTRY

In March, 1906, an act was passed by the legislature amending the act under which a state forestry bureau had been established in 1885, by transferring the work of the bureau to the Experiment Station and requiring investigation into the forest conditions of the State.

Such investigations had already been instituted by the Station, and under this act they were materially extended. In 1915 this act was supplemented by an act authorizing the purchase of lands suitable for the growth of forest trees at a price not exceeding $10 per acre and appropriating $10,000 for that purpose. Under authority of this act a tract of 221 acres was purchased in Athens County at $9 an acre, and one of 1,500 acres in Lawrence County at $4.50 an acre. These tracts were representative of many thousands of acres of steep, hillside land in southern Ohio that is wholly unfit for cultivation but is well adapted to the growth of forest trees, much of it being now covered with a dense growth of young trees which, if protected from exploitation and from fire, will grow into great value.

The State can exercise such protection more effectively than any private individual or corporation. Moreover, the long time during which capital must lie idle in such an enterprise is a discouragement to private investment. The question of taxation is another factor to be considered. Under State ownership there would be no taxes, but no way has yet been satisfactorily worked out by which such lands might be exempted from taxation under private ownership.

The investigations of the Experiment Station have opened the way for an effective and comprehensive State forest policy. The care of the State forests should be intimately associated and interwoven with thoroughgoing, scientifically directed research, covering the adaptation of forest growth to soil and climatic conditions on the one hand and to public utilization on the other, hence it is eminently proper that the Station should continue to be the State's agency for the care of the State forests.

SCIENTIFIC RESEARCH FUNDAMENTAL

Scientific research is indispensable to progress, not only in agricultural practice, but also in agricultural teaching and in law administration.

It was such research, in the experiment stations, that made possible the prevention of fraud in the trade in fertilizers, feeding stuffs and human foods and medicines.

It was such research by this Station that made possible the protection of the Ohio fruit growers by orchard and nursery inspection.

It was such research, to which this Station contributed, that made possible the control of tuberculosis in cattle.

It was such research that laid the foundation for the present trade in agricultural lime and limestone in Ohio.

The table showing the crop yields of Ohio shows that in all the great development of the mechanics of agriculture, from the crude hand implements of the 'fifties to the perfected machinery of the 'nineties, there was but a very meager increase in the product of the acre. It was not until the results of scientific research had become manifest in our fields that any conspicuous advance was made.

Thomas E. Wilson, president of one of the great packing companies in Chicago, writing in Chemical Age, says:

"When as a boy I entered upon my first job in the Union Stock Yards, Chicago, by no flight of imagination of the very practical men who laid the foundations of the industry could a chemical laboratory be conceived. * *

My own organization started with one chemist and now we have nearly a hundred of all kinds and descriptions, whose work in the study of the almost infinite details of a world-ramifying business has made possible its development to its present stage."

ADAMS FUND INVESTIGATIONS

Under the Act of Congress known as the Adams Act an annual appropriation of $15,000 is made to the experiment station in each state, which is expended only on investigational projects approved by the National Secretary of Agriculture. It has been the policy of the Secretary of Agriculture to devote this fund chiefly to the investigation of the more recondite problems in the sciences related to agriculture, including many which may apparently have only an indirect bearing upon the practical work of the farm.

Following is the present status of work that has been undertaken at this Station under this fund:

Project 1. Phosphorus combinations and availability in soils. Department of Chemistry. Work in progress.

Project 2. Relation of soil supply of phosphorus and nitrogen to the protein and carbohydrates of wheat. Department of Chemistry. A report of progress made in Bulletin 318.

The composition of the wheat grain is found to be modified by the fertilizer treatment of the soil. The addition of phosphorus increases not only the total yield but the size of the grain, and the addition of nitrogen increases the protein content of the grain and increases the total yield when reinforced with phosphorus.

Project 3. The sulphur requirements of crops. Department of Chemistry. Report of progress made in Bulletin 292.

Sulphates have apparently produced slight increase in yield of rape and leguminous crops on some Ohio soils, but no evidence has yet been found of such a great demand for sulphur as has been found in Oregon.

Project 4. Physiology of nitrification. Department of Soils. Reported upon in Bulletin 7, Technical Series, this Station, 1915; in the Journal of Bacteriology, Vol. IX, No. 1, January, 1919, and in the Botanical Gazette, Vol. 18, No. 3, September, 1919.

The work has thus far been devoted chiefly to technique. The results show that the ordinary Omelianski solution for the growth of the nitrate former will support a very abundant growth of this organism as measured by the production of the by-products of its growth, nitrous acid or its salts. The conditions under which this luxuriant growth was produced were (1) shallow layers of the solution, (2) slow rotary movement of the culture, and (3) a temperature of 25 to 30 degrees C. The growths reported are far in excess of any yet reported for equal periods of time in solution cultures. A fourth paper on "The Carbon Relations of the Nitrite Ferment" is now in course of publication.

Project 5. Azotobacter studies. Department of Soils. Reported in Annals of the Missouri Botanical Garden, Vol. 6, 1919. A second paper is now in course of publication.

This work also has been chiefly devoted to technique. The conclusion is reached that some of the markedly beneficial results observed in cultural solutions by different workers are associated with phosphorus nutrition of the organism and with maintenance of proper reaction of the medium.

Project 6. The role of phosphorus and other mineral elements in animal nutrition. Department of Nutrition. Progress reports in Bulletins 5 and 6, Technical Series, and in Bulletins 271, 283, 295, 308, 330 and 347 of the Monograph Series, of this Station.

The earlier years of this work were chiefly devoted to collecting the literature on the subject, Technical Bulletin No. 5 being a 700-page bibliography and review of the literature of phosphorus compounds in animal metabolism. The later work has shown that liberal milk production involves a certain degree of impoverishment of the skeleton in mineral substance; that rations which contain no leguminous roughage are apt to be definitely lacking in mineral nutriment, especially calcium; that the response of heavily-producing cows to liberal intake of mineral nutriment is remarkable for its inefficiency, it being apparently impossible by any method of feeding entirely to prevent loss of calcium, at least during the early part of the period of lactation, and that the mineral constituents of the skeleton appear to be more readily available for use in milk secretion than are nutrients directly absorbed from the ration.

Project 7. The increase and fixation of desirable qualities in cereals. Department of Agronomy. Progress report in Bulletin 298, and page xxi of this report.

The principal objects in view have been increase in yield; improvement in quality of grain and straw, and greater resistance to disease. Several strains have been selected out of standard varieties in which these qualities have been fixed to a marked degree, the new strains being more productive and stiffer in the straw than the parent stock. The results thus far attained give encouragement to the expectation of a large improvement in the wheat crop of the State.

Project 8. A study of variation in pure lines of winter wheat. Department of Agronomy. For report of progress, see page xix, this report. Numbers 7 and 8 are long-time investigations.

Project 9. A study of the methods of estimation of metabolic nitrogen. Department of Nutrition. Completed and reported in Journal of Agricultural Research, Vol. IX, page 405.

The final conclusions in this work are summarized as follows: In attempting to choose between these methods it seems to us that the acid-pepsin and the pepsin-pancreatin methods give results which are more nearly true than does Jordan's method, since the latter does not digest the bacteria, which may contain large proportions of the nitrogen of the feces and which presumably are more largely the product of digestible than of indigestible protein; but it is idle to attempt close comparisons of such conventional and inaccurate procedures. We have no accurate scientific basis for the determination of the digestibility of protein.

Project 10. A study of the effect of cereal diet on the capacity of the blood to combine with carbon di-oxide. Department of Nutrition. At present inactive.

Project 11. The physical analysis of soils. Department of Soils. Progress report in Journal of American Society of Agronomy, May, 1918. At present inactive.

Project 12. The determination of quartz in mechanical soil separates. Department of Soils. At present inactive.

Project 14. Sulphofication in relation to ammonification and nitrification. Department of Chemistry. Report in preparation.

Project 15. Factors relating to the lodging of the small grains. Department of Agronomy. Recently undertaken. For report of progress, see page xx, this report.

Project 16. Study of procedure for measuring possible changes in soil potassium produced by treatment and cropping. Department of Chemistry. Recently undertaken. For report of progress, see page xxiii, this report.

THE WORK OF THE YEAR

AGRONOMY

A number of minor experiments, suspended on account of the war, were resumed.

The following new investigations have been started during the year:

74. The effect on the yield of wheat of seeding timothy in wheat, and the comparative effect of fall and spring seeding.

75. The proportion of timothy in clover and timothy mixtures resulting from seeding the latter in wheat at different times.

76. Cultural and selection work with the annual strain of white sweet clover discovered by the Iowa Experiment Station.

Older investigations.*—No. 6. Effect of seed production on clovers. This test was so interfered with by insects and diseases that the results are inconclusive.

No. 9. Relation of bees and other insects to the development of clover seed.

On August 8, 1911, four equal areas of clover were covered with wire cages. In the first cage were put bumblebees; in the second, honey bees; in the third, miscellaneous insects (grasshoppers, crickets, butterflies, etc.) and in the fourth the blossoms were rubbed by hand. At harvest seed was gathered from an equal area of clover in the open field, this serving as a check. The test was repeated in 1912 and 1913.

So far as the production of clover seed is concerned all of these treatments were a failure except the bumblebees and the honey bees, and in 1 year only did the honey bees seem to increase seed production. In the bumblebees' cages the seed production each year was greater than on equal areas in the open field.

No. 12-B. Relation of fertility to yield of corn. Results reported in Bulletin 212, pp. 229-230.

No. 23. Thick and thin drilling of silage corn. Results reported in Bulletin 269, p. 169.

No. 25. Combinations of forage crops. Results reported in Bulletin 269, p. 189, also in Monthly Bulletin for March, 1919.

*For lists of earlier investigations see Bul 288, 300, 315 and 325

No. 29. Variety test of sorghums. Results reported in Monthly Bulletin for June, 1916.

No. 30. Forage crops for hogs. Reported by Department of Animal Husbandry.

No. 31. Varieties of legumes. Conducted for observation only.

No. 42. Inoculation of soil for soybeans. Commercial bacterial cultures found to be quite variable. Hardly as reliable as infected soil.

No. 44. Study of variation in pure lines of wheat. Progress reports in proceedings of the thirty-fifth annual meeting of the Society for the Promotion of Agricultural Science, p. 89, and in Vol. VIII, p. 409 of Proceedings of American Breeders' Association. Additional data now being prepared for publication.

No. 52. In the use of dynamite in preparing ground for alfalfa. No benefit was noted in the Wooster silt loam.

No. 64. Comparison of bacterial cultures. Results inconclusive as between different commercial bacterial cultures.

Seasonal notes.—Ice injury and the Hessian fly reduced wheat yields considerably below the average. The severe winter killing, however, made possible the selection of resistant pure lines of wheat.

Threshing was delayed, resulting in some injury to the grain, by 22 rainy days during the month of August. The August rainfall was 7.25 inches, or twice the average for the month.

ADAMS FUND WORK

Under the Adams Fund the following projects have been continued:

PURE LINE SELECTION (PROJECT 8)

Wheat.—During the year 1919-20 one thousand individual head selections of wheat were tested in the wheat nursery, representing the varieties Poole, Fultz, Nixon, Fultzo-Mediterranean, Harvest King, Dawson's Golden Chaff, Nigger and Gypsy. One hundred and six of these survived the severe winter of 1919 without apparent injury and were sufficiently promising in quality and yield to justify their further trial in triplicate rod-row test of 1920-21. The triplicate rod-row test of 1919-20 included all the varieties and older selections of the Station in addition to the 187 candidates from the 1918-19 head-to-row test, making 331 in all. Of the 99 strains and varieties that passed the requirements for promotion, 61 came from the 1918-19 selections. Two selections from Nigger, Nos. 18911 and 18947, were outstanding in quality of grain and hardiness. Two hundred and twenty-five different varieties of wheat were tested in single 50-foot rows. The variation in amount of winter killing was very great and furnished new material for the head selection work of 1920-21.

Oats.—The results with oats were interfered with by storms and wet weather during harvest. Several selections of Burt and Sixty Day were early enough to escape damage by the storms and the best of these will be carried on in the test for yield and quality.

Soybeans.—Three hundred plant selections of soybeans were tested. Unusual variation was noted. Several selections which showed desirable qualities will be continued.

Ear-to-row corn.—The ear-to-row corn work of 1920 further demonstrated the value of the progeny of ear No. 309 which was selected in 1905. These strains are being somewhat inbred and show marked reduction in vigor. Of the 68 ears entered in the test only five had a coefficient of yield greater than 100 and all of these trace back to ear No. 309.

Alfalfa and sweet clover.—Three alfalfa plants selected for resistance to leaf spot have been propagated by cuttings and grown in the nursery. One strain showed remarkable resistance to the disease and some seed was produced. This will be further tested. Fifty annual white sweet clover strains were tested. Only one gives promise of being of great value, since it alone was early enough to ripen seed this unfavorable season.

HYBRIDIZATION (PROJECT 7)

Hybridization work with wheat, oats and barley has made much progress. Five hundred pedigree selections of 10 wheat crosses are now growing in the wheat nursery. Barley crosses are being carried on as a greenhouse project; nothing of economic value having been found to date. The oats cross, Avena nuda x Avena sterilis, has produced a few promising segregates. One of note, No. 3001-2-30, shows a mean development in size exceeding either parent. The wheat x spelt cross in the F2 last year was tested for resistance to stinking smut. A few resisting segregates were apparently secured. These are being further tested.

LODGING OF SMALL GRAIN (PROJECT 15)

During the year work has consisted of greenhouse experiments and field observations.

Moisture determinations made on the stems of plants grown in the greenhouse last winter indicate that the points just above the nodes are the weak spots. However, determinations of breaking strength made on plants soon after the first appearance of the heads while the stems and leaves are both green, show that at that stage of growth the breaking of the stem occurs almost always below the nodes, thus indicating that even though the weak points in the culms are immediately above the nodes, yet the support offered by the green leaf sheath is such as to render that part of the stem stronger than is the part just below the nodes. As the plants approach maturity and the leaves begin to dry and the sheath begins to loosen its hold around the stem, then the stems almost invariably break above the nodes.

Wheat grown in the greenhouse last winter in three different sets of jars, to each of which was applied a different quantity of water, showed that with an increase of water in the soil there was,

at least within certain limits, a corresponding increase in the water content of the stems of wheat grown on that soil.

In the summer of 1920 many observations were made in the field on the lodging of oats. Differences of moment were observed and photographs of some were taken where oats were grown under different conditions as indicated below:

Erect	Lodged
Thin seeding (4 to 7 pecks)	Thick seeding (10 to 14 pecks)
Large seed	Small seed
No preparation of seed bed	Seed bed plowed
No treatment or incomplete fertilizer	Complete fertilizer

Publications.—*Monthly Bulletin*: "Constructive Rotations" (July, 1919), J. F. Barker; "Eight-inch vs. Four-inch Drilling of Grain" (August, 1919), F. A. Welton; "Clipping Tests of Oats and Wheat" (January, 1920), C. G. Williams; "Experiments with Oats" (March, 1920), F. A. Welton.

ANIMAL HUSBANDRY

This department remained under control of the Wayne County court of common pleas throughout the year, the Director and the Board of Control having been enjoined on January 31, 1919, from "interfering" with its chief "in any way in the use of his office and in the work of his department."

Under the protection of this order the chief of this department has refused to furnish any report for publication on the experiments with horses and cattle which he has conducted since 1908. His subordinates have furnished the reports listed below:

Publications.—Bulletin 340,* "Green Forage Crops and Corn for Fattening Lambs," J. W. Hammond; Bulletin 343, "The Use of Forage Crops in the Fattening of Pigs," W. L. Robison. *Monthly Bulletin*: "Does it Pay to Feed Corn to Fattening Lambs on Pasture?" (July, 1919), J. W. Hammond; "Selection of Rations for Egg Production" (September, 1919), W. J. Buss; "Winter Rations for Brood Sows" (December, 1919), W. L. Robison; "Methods of Feeding Laying Hens" (January, 1920), W. J. Buss; "Soybean Oilmeal as a Feed for Swine" (April, 1920), W. L. Robison.

BOTANY

Following is the present status of the major investigations by the department of botany as enumerated in the 34th Annual Report:

1. **Naming of weeds and other plants.**—The plant and weed specimens sent for identification have considerably increased in number. This arises either from the nature of the season or from the increased effort of the county agricultural agents in calling attention of county residents to the plants of their surroundings.

2. **Examination of seeds for purity and germination.**—This work has been taken over by the seed inspection service of the State Department of Agriculture, thus releasing the experiment station.

*Manuscript submitted August, 1918.

3, 4. **Investigation of causes and control measures for orchard and small fruit diseases.**—The study of apple blotch has been reported upon in Bulletin 333. The study of the effect of winter freezing on young orchards is being continued, as also is the study of the relation of insects to the spread of blight organisms, and that of bark disease organisms.

5, 6. **Diseases of forest and shade trees and ornamental plants and shrubs.**—There has been continued demand for attention and advice under this head.

7. **Diseases of cereals and forage crops.**—Intense efforts have been made in the study of the diseases of cereals, including not only the small grains but especially the diseases of corn, the root rot disease of which is not only a serious disease of field corn but is carried over and attacks wheat following corn.

8. **Diseases of vegetables in greenhouse and field.**—Effort is being continued to breed strains of tomatoes resistant to the fusarium wilt of that crop, and the prominence of the potato in the dietary of the people has necessitated increased attention to the diseases of that crop. The latest reports on this work are Bulletin 319, "Ohio Potato Diseases," and Bulletin 321, "Tomato Diseases in Ohio.'

In the diseases of greenhouse crops the effort has been to investigate all serious troubles of vegetables grown under glass. A lettuce disease, new to this region, was reported upon by Roy C. Thomas in the Monthly Bulletin for January, 1920.

9. **Tobacco studies.**—The study of diseases of tobacco and the efforts to control root rot by particular rotations of the crop and by sand or other coverings of the seed bed in which the disease exists have been continued. The steaming of the plant beds to dstroy the root rot fungus continues to be the most practicable method of control.

Publications.—*Monthly Bulletin*: "Wheat Scab Serious in 1919" (August, 1919), A. D. Selby; "Broken-Stem Disease of Rye" (August, 1919), Freda Detmers; "Corn Smut in Ohio" (October, 1919), Wayne VanPelt; "Keeping Seed Potatoes from Disease Attacks" (November, 1919), Roy C. Thomas; "A New Lettuce Disease" (January, 1920), Roy C. Thomas.

CHEMISTRY

The work of this department has been chiefly in connection with soil investigations. In addition to the definite projects undertaken, it has been necessary to do a considerable amount of work of a miscellaneous character. This has been due to the increasing number of inquiries received regarding treatment of soil, and the adaptability of local limestone and marl deposits for use on the owner's land.

The principal investigations in progress during the past year have included the following projects:

PHOSPHORUS COMBINATIONS AND AVAILABILITY

(a) **Organic phosphorus** (Adams Fund, Project 1).—One phase of the subject of the combination and availability of phosphorus in soils has been a study of the influence of soil reaction and of cultivation upon the soils' content of phosphorus in organic combinations. The results obtained have led to the

conclusion that the reaction of the soil is practically without influence upon the proportion of the total phosphorus which is present in the organic form. The organic phosphorus compounds of a number of soils, both acid and basic, cultivated and virgin, were apparently quite similar in nature, although there were large variations in the actual amounts present in various soils. The results have shown that cultivation and cropping appreciably decrease the total and the organic phosphorus, and in practically the same ratio. From averaged figures one-third the total phosphorus of surface soils, and one-fifth that of subsoils is in organic combinations. The amounts of phosphorus in organic combinations seem to bear a rather close relation to the total organic matter and nitrogen in the soils examined. The evidence obtained does not indicate that the organically combined phosphorus of the soil is of a high order of availability.

(b) **Effect of fertilizers on availability of rock phosphate as indicated by the phosphorus content of the oat plant.**—The object of the work has been to determine whether the larger yield of crop obtained in some instances from rock phosphate, when other fertilizers have been applied, is due to their increasing the availability of the phosphate, or whether the stimulation of plant growth has enabled the crop to more readily assimilate phosphorus required for increased weight of crop.

It has been found that the phosphorus content of the oat plant where rock phosphate was applied was considerably in excess of that of the crop grown on soil not treated with rock phosphate. The most decided indication was obtained from the oats sampled 8 weeks after seeding. The percent of phosphorus at this time was more than twice that of the mature crop. The yield of the oat crop studied was increased by rock phosphate. While the addition of other fertilizers produced a further increased yield with a larger removal of phosphorus, no very definite indications that the fertilizer treatment on individual plots affected the availability of the rock phosphate have been obtained.

2. **Sulphur in relation to soils and crops** (Adams Fund, Project 3).—Additions of sulphur and sulphates have not increased the yields of corn, oats, wheat, soybeans, potatoes and clover grown on experimental plots. Sulphur has increased the acidity of the soil and the solubility of certain mineral constituents.

3. **Potassium supply of soil** (Adams Fund, Project 16).—This project is being carried on to determine whether fertilizers and lime tend to increase the solubility of potassium; and the effect of cropping on the depletion of the available supply. The results obtained show that the concentration of the soil solution with respect to potassium varies appreciably, depending on the soil texture and the treatment.

The effect of treatment on the soluble potassium content appears to be due to the larger removal by crops where conditions are more favorable for crop growth, rather than to the direct action of the additions on the potassium bearing minerals of the soil.

The soluble potassium content of unfertilized soil is greater than that of soil where the treatment has caused increased yields.

Lime and acid phosphate have had a pronounced effect on the removal of available potassium in this manner from a silt loam soil.

Other investigations not classed as Adams projects are as follows:

Influence of silicates on growth of plants and on their utilization of phosphorus.—Treatment of acid soil with various silicates, including blast furnace slag, partially satisfies the requirement for bases and increases growth of legumes. No effect of a greater utilization of phosphorus by plants growing on silicate-treated soil has been observed.

Milling and baking technology.—Wheats grown by the Agronomy Department are milled to determine whether they will produce flour of suitable quality for baking. Studies of the factors influencing the quality of flour are included in this work.

Publications.—*Monthly Bulletin*: "Bread-making Qualities of Ohio Wheats" (September, 1919), Mabel Corbould; "Supply of Nitrogen in the Soil" (June, 1920), J. W. Ames; *Soil Science* (Vol. VIII, No. 4, October, 1919), "Calcium and Magnesium Content of Virgin and Cultivated Soils," J. W. Ames and C. J. Schollenberger.

DAIRYING

The status of lines of work enumerated under the projects in the Thirty-fourth and Thirty-eighth reports is as follows:

1. **Wide, medium and narrow rations.**—This work was begun in 1911, by selecting three groups of cows and placing them on rations containing a deficiency, a normal supply, and an excess of protein. They receive no green feed and are never outside the barn or barn lot. It was planned to continue the test through several generations. Difficulties have arisen in the form of an excess of male calves and of abortion. All of the original cows except one have been removed from the test.

Thus far, little difference has been observed in the effect of the rations. The cows receiving an excess of protein are milking better than the others; all the cows are much less thrifty in appearance than the remainder of the herd, which runs on pasture during the summer season, and there is more trouble with indigestion than with those on pasture. This applies to all groups, and appears to be due to dry feed and lack of exercise.

This work will continue for some time before any attempt is made to draw definite conclusions.

2 and 3. Comparison of alfalfa and clover and cost of raising dairy heifers. Reported in Bulletins 289 and 327.

4. **Effect on composition of milk and butterfat of various feeds.**—Studies being continued.

5. **Effect of inbreeding.**—This work is still in progress. One family of Jerseys and one of Holsteins are being used. The second generation has shown no deleterious effect.

6. **Cost of milk production.**—Reported in Bulletin 334 and for the present discontinued.

7. **Calf rations.**—Temporarily suspended.

8. **Silage comparison.**—Four tests have been completed, comparing silage made from the large ensilage corn with that made from the ordinary field corn. These tests have been made in cooperation with the Department of Agronomy, and show better results, ton for ton, from the field corn; but the difference is small and may not overbalance the difference in yield per acre. A fifth test is in progress.

9. **Herd improvement.**—This work is being continued at the Central Station and similar work is being conducted on some of the county experiment farms in cooperation with the Department of Farm Management.

Considerable improvement has already been accomplished, as shown by the following records of semi-official tests made during the last year:

Cow No. 70—Holstein—17,521 lb. milk; 588 lb. fat—10-year-old
Cow No. 65—Holstein—18,300 lb. milk; 505 lb. fat—11-year-old
Cow No. 57—Holstein—21,190 lb. milk; 718 lb. fat—12-year-old
Cow No. 161—Holstein—11,600 lb. milk; 363 lb. fat— 3-year-old
Cow No. 143—Jersey—10,165 lb. milk; 580 lb. fat— 5-year-old

Others are doing equally well, and a daughter of No. 57 is exceeding the record of her dam.

Publications.—*Monthly Bulletin*: "The Ohio Experiment Station Dairy Herd" (July, 1919), C. C. Hayden; "Recovering Cottage Cheese Curd from Buttermilk" (September, 1919), A. E. Perkins; "Home-mixed or Proprietary Feeds for the Dairy Herd" (October, 1919), A. E. Perkins; "Usefulness of Productive Records in Dairy Management" (December, 1919), A. E. Perkins.

ENTOMOLOGY

Of the projects listed in the 34th report, **1. Studies of plant lice,** has been partially reported upon in Bulletin 311. The work is being continued, and a large collection of aphids is available for future study.

2. **Relation of insects to transmission of fire blight.**—A study conducted in cooperation with the Department of Botany. A report on this work is being prepared.

3. **Distribution of periodical cicada.**—Data concerning the brood of 1919 were collected but have not yet been prepared for publication.

4. **Life history of the codling moth.**—Valuable data have been collected for 2 seasons at Marietta which will be added to data previously collected at Gypsum and published after one or two more seasons' complete records have been obtained.

5. **Control of leaf-hoppers in grass lands.**—This project is in the hands of Professor Osborn, Associate Entomologist, who has nearly completed a comprehensive bulletin on the insects of pastures and forage crops in Ohio.

6. **Effect of long-time spraying on orchards.**—Progress reports have been made in Monthly Bulletins for May, June and July, 1919.

7. **Life history of clover-leaf roller.**—Completed and published in Bulletin 297.

8. **Studies of the more resistant scales and leaf-eating caterpillars,** and **9, Insect control on city shade trees,** were reported on in Bulletin 332.

10. **Tests of efficiency of newer insecticides.**—Reported on in Monthly Bulletins for January, 1916, February, 1920, and May, 1920; also in several reports of the Ohio State Horticultural Society.

11. **Control of woolly aphis** has been merged with **No. 1.**

12. **Control of onion maggot.**—Work being continued.

13. **Control of insects in stored grain.**—Results not yet published.

14. **Control of the grape-berry worm.**—Reported on in Bulletin 293.

15. **Studies of wood boring beetle, and 16, Studies of the nut weevils.**—Work discontinued because of reduction in personnel.

17. **Studies of the stink-bug family.**—Partly reported in Bulletin 310. Another bulletin partly prepared.

18. **Studies in bee-keeping.**—Not undertaken because College of Agriculture had undertaken similar work.

19. **Control of household insects.**—Work reported in Bulletin 253.

20. **Control of peach-tree borers.**—Reported in Bulletins 307 and 329.

21. **Studies of the bark beetles.**—Partly reported in Bulletin 264. Discontinued because of reduction in personnel.

In addition to the foregoing, a general investigation of insects affecting truck crops has been undertaken and a laboratory has been established at Marietta for this purpose. At this laboratory the life history of the striped cucumber beetle has been determined and an effective control discovered. A bulletin on this subject is nearly ready for publication. An investigation on the apple flea weevil has also been completed.

The work of this department has been seriously interrupted by the loss of members of its personnel, who resigned in order to accept positions offering much higher salaries than could be paid here.

Publications.—Bulletin 341, "The Chrysanthemum Gall Midge," T. L. Guyton. *Monthly Bulletin*: "Decade Records in Ohio Orchards" (July, 1919), H. A. Gossard; "Winter Work in Shade-tree Insect Control" (November, 1919), J. S .Houser; "European Corn-borer not in Ohio" (November, 1919), H. A. Gossard; "Insects Resembling European Corn-borer" (November, 1919), H. A. Gossard; "Recent Tests of Material to Control San Jose Scale" (February, 1920), J. S. Houser; "Dust Spraying" (May, 1920), H. A. Gossard; "Watch for Chinch-bugs" (June, 1920), H. A. Gossard.

FARM MANAGEMENT

The work of this department is the supervision and coordination of the work on the outlying farms attached to the Experiment Station. Thirteen such farms are now in operation, in as many counties, three of which are owned by the Station and 10 are owned by the counties in which they are located, but are operated by the Station.

These farms serve the double purpose of extending the Station's field of research to regions in which the soil formations, climatic conditions and agricultural industries differ materially from those in Wayne County, and of demonstrating to the farmers in these regions the effect of different soil and crop treatments under their own conditions.

To illustrate: The culture of the sugarbeet in Ohio is limited to the "black land" counties in the northwestern quarter of the

State, and experiments on this crop on such soils as those of eastern Ohio would be valueless to the farmer who is growing sugarbeets. But the Paulding County experiment farm is located in the midst of the sugarbeet area, on a typical soil, and within a mile and a half of a great beet sugar factory. For these reasons the experiments with sugarbeets are made a leading feature of the work of this farm.

For similar reasons tobacco work is located in the midst of the tobacco-growing area in southwestern Ohio, and work with truck crops is centered in the Marietta district, with smaller tests in reach of the Cincinnati and Youngstown markets.

The thin, acid soils of Northeastern Ohio are well represented in the Trumbull County experiment farm; the rolling hills of southeastern Ohio, in the Belmont County and Washington County farms and the rich corn-and-hog country of the Miami Valley in the Miami County farm.

It is probable that no tract of land in Ohio or elsewhere is naturally better adapted to a thoroughgoing study of the wheat plant or the apple tree than that occupied by the Experiment Station in Wayne County, but for this very reason it is absolutely necessary that work with these plants, which are of such fundamental importance to humanity, should be extended over regions whose soils and climatic conditions are less favorable.

Publications.—The work of the county experiment farms is being reported biennially, the last report being Bulletin 344, just issued. In the *Monthly Bulletin* for May, 1920, is published a paper on "Factors Affecting Labor and Miscellaneous Costs of Producing Crops" by C. W. Montgomery.

FORESTRY

In this department the following lines of work are under way:

1. **Propagation of forest trees.**—(a) Fertilization. This work is being continued. Experiments are under way on state forests. (b) Methods of sowing seeds for the production of forest planting stock.

2. **Reforestation.**—Methods of planting forest trees, adaptability of species for plantations, windbreaks and shelter belts.

3. **Forest arboretums.**—This work is being conducted on State, municipal and private lands for the purpose of more intensive investigations relative to the value of different species for reforestation in pure stands and mixtures. Spacing and behavior on different soils and sites are also being studied.

4. **Forest management.**—(a) Thinning experiments with catalpa are being conducted on the 150-acre plantation of H. C. Rogers in Champaign County. This work was begun in 1916 and will be carried through a period of several years. (b) Experiments in the improvement and reconstruction of farm woodlands are being continued in cooperation with land owners in the various parts of the State.

5. **Wood utilization.**—(a) Investigation on the relative durability of fence post timbers is being continued. (b) A census of the standing timber of the State, its distribution by species, with supplemental data on timber markets, has been prepared for publication and is in the hands of the printer.

6. **Municipal forestry.**—Cooperation with the cities of Cincinnati and Oberlin in the establishment of municipal forests is being continued under the direction of the Station Forester. Arrangements have been made for cooperation with the Miami Conservancy District in carrying out an extensive reforestation project in that district.

7. **The State forests.**—Operations on the Dean and Waterloo forests are continued. During the year, 7,149 trees were planted in experimental plantations at Waterloo, while the nursery was enlarged by 30,000 trees. The Dean nursery was enlarged by 80,795 trees. The aboretum plantings on the two forests were increased by the addition of 17 plots of different species or mixtures of species.

8. **Commercial tree studies.**—Data on the white ash have been gathered in the field, and office compilation is practically completed.

9. **Forest surveys.**—The field data on forest surveys of Scioto and Pike Counties were completed and office work in mapping and compiling data is now in progress.

Publications.—*Monhtly Bulletin*: "The Waning Timber Supply" (September, 1919), Edmund Secrest; "The Black Walnut" (October, 1919), Edmund Secrest; "Salient Features of a Policy of Forestry for Ohio" (January, 1920), Edmund Secrest; "Concrete and Steel Fence Posts" (April, 1920), J. J. Crumley; "Protection for Shade Trees" (June, 1920), Edmund Secrest.

HORTICULTURE

The work of this department has gone on mainly along the lines mentioned in the last report. None of the lines of work have been terminated, although some have been conducted far enough to warrant progress reports.

Fruit juices.—A preliminary report has been made on this work in the Monthly Bulletin for August, 1919, but there remains much to be done. Further work should include the manufacture and preservation of sweet cider or apple juice; simple home methods of grape juice manufacture, and the use of other varieties than Concord and Catawba both by themselves and in combination.

Currant varieties.—The variety collection of currants, which has been pronounced by competent authority to be the best in the United States if not in the world, has been added to. Unforseen circumstances prevented the preparation of a report on Currant Nomenclature this season.

Peach fertilization.—The experiment in the fertilization of peach orchards has been running several years and a preliminary report has been made in the Monthly Bulletin for December, 1919. At present a great deal of interest is manifested in this line of work by the peach growers of northern Ohio.

Tree records.—For 10 years a record has been kept of the blooming dates, time of picking and yield of bearing apple trees in the Station orchard. These figures are valuable and a summary is being prepared for publication.

County experiment orchards.—The orchards on the county experiment farms are coming into bearing and these, together with the ornamental planting around the residences on these farms, are bringing home to the farmers the work of the department.

Pruning.—Tests of different methods of pruning are being carried on, both at Wooster and on the county experiment farms. In the Monthly Bulletin for March, 1920, Mr. Ballou gives some of the deductions already drawn from these pruning plots.

Lettuce.—The new greenhouses have been largely given over to the growing of lettuce and tomatoes, with a spring crop of cantaloupes and cucumbers in two of the beds. The outstanding features have been the great superiority of the two Station strains of Grand Rapids lettuce over the ordinary seedsmen's stock, and the high yield of lettuce seed on undisturbed plants in the beds over potted seed plants or over the out-of-door seed plots. It is designed to devote the greenhouses almost wholly to the improvement of varieties of vegetables.

Sweet corn.—The work with ear-row tests, mentioned in the last annual report, has been continued but is not yet far enough along for a report.

Mulching.—The comparison of cultivation, irrigation and mulching, on different vegetables, has been conducted for two seasons and promises to show the value of mulch even in a wet season.

Publications.—"Orchard Rejuvenation in Southeastern Ohio," Bulletin 339, F. H. Ballou and I. P. Lewis. *Monhtly Bulletin*: "Using an Apple Sizer" (July, 1919), I. P. Lewis; "Making Grape Juice," and "Varieties of Grapes for Juice" (August, 1919), Paul Thayer; "Autumn Planting of Hardy Perennials" (September, 1919), W. E. Bontrager; "Fruits of Unusual Excellence" (November, 1919), C. W. Ellenwood; "Apple Varieties Adapted for Ohio Culture" (November, 1919), W. J. Green and Paul Thayer; "Fertilizers for Peach Orchards" (December, 1919), Paul Thayer; "The Bartlett Plum" (January, 1920), Paul Thayer; "Bearing Habits of the Delicious Apple" (January, 1920), C. W. Ellenwood; "What Shade and Ornamental Trees Shall We Plant?" (February, 1920), W. E. Bontrager; "Culture and Feeding of the Apple Orchard" (February, 1920), F. H. Ballou and I. P. Lewis; "Horticultural Notes from the County Experiment Farms of Ohio" (February, 1920), F. H. Ballou and I. P. Lewis; "Selecting Nursery Stock" (February, 1920), Paul Thayer; "Smudging to Prevent Frost" (February, 1920), W. J. Green; "Pruning Tests in Young Apple Orchards" (March, 1920), F. H. Ballou and I. P. Lewis; "Broad-leaved Evergreens for Ohio Planters" (April, 1920), Department of Horticulture; "Thinning of Apples, Peaches and Plums" (May, 1920), C. W. Ellenwood and Paul Thayer; "Varieties of Apples Adapted for Ohio Culture" (June, 1920), W. J. Green, Paul Thayer and J. B. Keil.

NUTRITION

The work of the Department of Nutrition for the past year has been a continuation of its program of study of the mineral nutrients, all conducted under the Adams Fund.

The main work has been a fourth series of mineral balance experiments with milch cows under Project 6, the subjects being so selected as to represent practically the whole of the annual cycle

of lactation and gestation. The plan of the investigation has been extended by the addition of a study of the metabolism of arsenic, this departure having become desirable through the use of arsenic in the compounding of commercial mineral feeds, especially since arsenic is eliminated in part in the milk.

A study of the alkali reserve of swine demonstrated the fact that the acid-neutralizing capacity of the blood serum may be altered in marked degree by the acidity or alkalinity of mineral supplements fed with a cereal ration. This fact suggests that the potential mineral acidity of cereal rations may, in the course of time, effect the resistance of swine to disease.

Studies have also been made of the effects of several calcium and phosphorus compounds and preparations on the development of the skeleton of swine; and of the palatability of mineral salt mixtures to cattle, horses and swine.

Publications.—*Monthly Bulletin*: "Vitamines in Human Nutrition" (October, 1919), E. B. Forbes; "Utilization of Calcium Compounds by Growing Swine" (November, 1919) E. B. Forbes, J. O. Halverson, J. A. Schulz and E. B. Wells.

SOILS

DIVISION OF SOIL TECHNOLOGY

Soil biology.—The work of this division is reported under Adams Fund projects 4 and 5.

Soil survey.—This work, conducted in cooperation with the Bureau of Soils, U. S. Department of Agriculture, and with the State University, has been limited to the survey of Fulton County and a revision of the survey of Wayne County, only 3 men being engaged in it because of insufficiency of funds and difficulty in securing capable men. We believe that the work is being very thoroughly done.

DIVISION OF SOIL TREATMENT

The field experiments with fertilizers and manures have been carried forward during the year. A table at the end of Bulletin 344 shows the general outcome of these experiments.

Publications.—**Bulletin 344,** "County Experiment Farms in Ohio" (June, 1920), C. W. Montgomery and others. *Monthly Bulletin*: "Fertilizing the Wheat Crop of 1920" (August, 1919), C. E. Thorne; "Various Benefits from Tile-drainage" (October, 1919), Firman E. Bear; "Basic Slag vs. Acid Phosphate" (March and May, 1920), C. E. Thorne; "Fertility Program for a 160-Acre Farm" (April, 1920), C. E. Thorne; "Facts Concerning Meadow Fertility" (April, 1920), M. A. Bachtell; "A Crop Rotation for a Hog Farm" (May, 1920), C. E. Thorne; "The Maintenance of Soil Fertility in Hamilton County" (June, 1920), C. E. Thorne.

PERSONNEL

The following changes in the personnel of the scientific and managerial staffs of the Station have occurred during the year:

APPOINTMENTS

C. E. Dike, field assistant in agronomy; W. V. Balduf, assistant in entomology; F. W. Dean, assistant in forestry; J. B. Keil, field assistant in horticulture; C. H. Hunt, A. R. Winter and R. F. Remler, assistants in nutrition; D. S. Kirby, foreman, Northeastern Test Farm.

RESIGNATIONS

Wayne Van Pelt, assistant in botany; J. W. Calland, assistant in forestry; J. O. Halverson, assistant in nutrition; E. R. Allen, associate in soils; B. S. Davisson, assistant in soils; W. H. Ruetenik, foreman, Northeastern Test Farm; C. L. Higginbotham, horticultural foreman, Hamilton County Experiment Farm.

In concluding this, my thirty-third and final report as Director of this Station, I wish to bear testimony to the conscientious and unselfish labors of the present Board of Control in conducting the Station through the most difficult period in its history, and to express my high appreciation of the unwavering courtesy that has been shown to me personally by every member of the Board of Control and by the very great majority of the members of the Station staff.

Respectfully submitted,

CHAS. E. THORNE,

Director.

REPORT OF THE BURSAR

HON. G. E. JOBE,

President of the Board of Control.

Sir: I respectfully submit the financial report of the Ohio Agricultural Experiment Station for the fiscal year ended June 30, 1920.

In statements A, B, C, D, E, F and G will be found a record of the receipts and expenditures from the various funds; statements A and B being statements of account with the appropriations received from the National Government and a copy of the report made to the Governor of the State, to the National Secretary of Agriculture, and to the National Secretary of the Treasury; statement C being a statement of account with the United States Produce Fund; statement D being a statement of the account with the State appropriations and Produce Fund; statement E being a statement of account with the Rotary Funds.

The five statements, A, B, C, D and E, are combined in statement F, which shows the total income and expenditures for the fiscal year.

Statement G is a balance sheet which shows the condition of each fund at the close of business, June 30, 1920.

Respectfully submitted,

W. H. KRAMER,

Bursar.

STATEMENT A

HATCH FUND

The Ohio Agricultural Experiment Station in Account with the United States Appropriation under the Hatch Act for 1919-20

Dr.

To receipts from the Treasurer of the United States, as per appropriation for the fiscal year ended June 30, 1920, as per act of Congress approved March 2, 1887	$15,000.00

Cr.

By expenditures for:		
Salaries	$6,130.37	
Wages	1,067.71	
Forage supplies	2,170.62	
Office supplies	56.01	
Agricultural supplies	1,140.38	
General plant supplies	267.51	
Building material	513.50	
Agricultural equipment	155.00	
Educational equipment	750.00	
General plant equipment	2,179.56	
Repairs	233.74	
Light, heat and power	13.07	
Freight, express and drayage	213.05	
Communication	109.48	
Total		$15,000.00

STATEMENT B

ADAMS FUND

The Ohio Agricultural Experiment Station in Account with the United States Appropriation under the Adams Act for 1919-20

Dr.

To receipts from the Treasurer of the United States, as per appropriation for the fiscal year ended June 30, 1920, as per act of Congress approved March 16, 1906	$15,000.00

Cr.

By expenditures for:		
Salaries	$8,878.13	
Wages	2,496.85	
Forage supplies	245.88	
Office supplies	26.89	
Cleaning supplies	5.50	
General plant supplies	603.98	
General plant materials	120.34	
Livestock	213.92	
Educational equipment	588.03	
General plant equipment	1,731.94	
Repairs	56.75	
Freight, express and drayage	31.79	
Total		$15,000.00

STATEMENT C

ADAMS PRODUCE FUND

The Ohio Agricultural Experiment Station in Account with the United States Produce Fund

Dr.

To Receipts

From	Sale of cattle	$1,393.58	
"	Sale of hogs	1,206.66	
"	Sale of milk	163.84	
"	Sale of miscellaneous items	157.90	
	Total		$2,921.98
	To balance forward July 1, 1919		2,957.93
	Total		$5,879.91

Cr.

By Expenditures

Wages	$ 812.36	
Forage supplies	829.02	
General plant supplies	11.68	
Building materials	46.18	
General plant materials	14.49	
Livestock	2,560.51	
General plant equipment	14.50	
General plant service	1.85	
Total		$4,290.59
By balance forward		1,589.32
Total		$5,879.91

STATEMENT D

The Ohio Agricultural Experiment Station in Account with the State and Produce Funds

Dr.

To Receipts

From	State appropriations	$279,035.00	
"	Department of Administration	1,431.67	
"	Department of Agronomy	3,843.88	
"	Department of Animal Husbandry	17.01	
"	Department of Botany	11.25	
"	Department of Forestry	649.81	
"	Department of Horticulture	10,172.61	
"	Northeastern Test Farm	1,248.25	
"	Northwestern Test Farm	419.30	
"	Southeastern Test Farm	1,047.76	
"	Southwestern Test Farm	713.65	
	Total		$298.590.19
	To balance forward July 1, 1919		113,333.37
	Total		$411,923.56

Cr.

By Expenditures

For	Salaries	$117,592.16	
"	Wages	57,315.68	
"	Wages, unclassified	120.00	
"	Forage supplies	9,925.96	
"	Fuel supplies	7,049.21	
"	Office supplies	1,504.74	
"	Cleaning supplies	47.28	
"	Agricultural supplies	1,911.51	
"	General plant supples	7,942.21	
"	Building materials	439.97	
"	General plant materials	2,337.18	
"	Office equipment	193.56	
"	Livestock	250.00	
"	Agricultural equipment	340.00	
"	Wearing apparel	21.65	
"	Educational equipment	917.46	
"	General plant equipment	6,054.20	
"	Repairs	1,906.27	
"	Light, heat and power	210.30	
"	Freight, express and drayage	2,008.54	
"	Traveling expense	10,751.91	
"	Communication	463.44	
"	General plant service	573.29	
"	Grenhouses	1,862.82	
"	Fencing	685.43	
"	Paving	2,181.07	
"	Rent	2,717.47	
"	Insurance	58.75	
"	Contributions	25.00	
	Total		$237,407.06
	*State Treasury		19,555.19
	By balance forward		154,961.31
	Total		$411,923.56

*Deposited in State Treasury to the credit of the General Revenue Fund.

STATEMENT E

Ohio Agricultural Experiment Station in Account with the Animal Husbandry and Dairy Rotary Funds

ANIMAL HUSBANDRY ROTARY FUND

Dr.

To Receipts

From	Sale of cattle	$ 3,105.00	
"	Sale of eggs	4,244.92	
"	Sale of hogs	8,978.49	
"	Sale of horses	265.00	
"	Sale of poultry	820.35	
"	Sale of sheep	2,242.09	
"	Sale of sheep pelts	18.62	
"	Sale of wool	4,849.54	
"	Sale of miscellaneous items	2.13	
	Total		$24,526.14
	To balance forward July 1, 1919		5,418.32
	Total		$29,944.46

Cr.

By Expenditures

For	Wages	$ 9,259.25	
"	Forage supplies	15,085.05	
"	Cleaning supplies	50.19	
"	Agricultural supplies	2.80	
"	General plant supplies	64.50	
"	Livestock	151.27	
"	General plant equipment	223.67	
"	Repairs	20.70	
"	Freight, express and drayage	629.39	
"	General plant service	49.36	
"	Contributions	1.00	
	Total		$25,537.18
	By balance forward		4,407.28
	Total		$29,944.46

STATEMENT E—Concluded

DAIRY ROTARY FUND

Dr.

To Receipts

From	Sale of cattle	$1,132.36	
"	Sale of milk and cream	8,532.28	
"	Miscellaneous items	6.80	
	Total		$ 9,671.44
	To balance forward July 1, 1919		2,392.05
	Total		$12,063.49

Cr.

By Expenditures

For	Wages	$7,412.83	
"	Forage supplies	2,371.09	
"	Cleaning supplies	22.05	
"	General plant supplies	15.41	
"	General plant materials	3.50	
"	Wearing apparel	32.71	
"	General plant equipment	43.44	
"	Repairs	1.60	
"	Freight, express and drayage	332.04	
"	General plant service	237.56	
	Total		$10,472.23
	By balance forward		1,591.26
	Total		$12,063.49

STATEMENT F

Total Receipts and Expenditures of the Ohio Agricultural Experiment Station for the Year ended June 30, 1920

Dr.

To Receipts

From	United States appropriation	$ 30,000.00
"	State appropriations	279,035.00
"	Adams Produce Fund	2,921.98
"	State Produce Fund	19,555.19
"	Rotary funds	34,197.58
	Total	$365,709.75
	To balance forward July 1, 1919	124,101.67
	Total	$489,811.42

Cr.

By Expenditures

For	Salaries	$132,600.66
"	Wages	78,364.68
"	Wages, unclassified	120.00
"	Forage supplies	30,627.62
"	Fuel supplies	7,049.21
"	Office supplies	1,587.64
"	Cleaning supplies	125.02
"	Agricultural supplies	3,054.69
"	General plant supplies	8,905.29
"	Building materials	999.65
"	General plant materials	2,475.51
"	Office equipment	193.56
"	Livestock	3,175.70
"	Agricultural equipment	495.00
"	Wearing apparel	54.36
"	Educational equipment	2,255.49
"	General plant equipment	10,247.31
"	Repairs	2,219.06
"	Light, heat and power	223.37
"	Freight, express and drayage	3,214.81
"	Traveling expenses	10,751.91
"	Communication	572.92
"	General plant service	862.06
"	Greenhouses	1,862.82
"	Fencing	685.43
"	Paving	2,181.07
"	Rent	2,717.47
"	Insurance	58.75
"	Contributions	26.00
	Total	$307,707.06
	*State Treasury	19,555.19
	Balance forward	162,549.17
	Total	$489,811.42

*Deposited in State Treasury to the credit of the General Revenue Fund.

STATEMENT G
Balance Sheet, June 30, 1920

Date of appropriation	Apprpropriate titles	Balance July 1, 1919	Appropriation	Receipts transfers	Total	Lapsed to State Treasury	Expenditures	Balance June 30, 1920
1917–18	Salaries	$13,870.75			$13,870.75			13,870.75
	Wages	12,468.49			12,468.49			12,468.49
	Wages unclassified	500.00			500.00			500.00
	Food supplies	25.00			25.00			25.00
	Livestock	11.00			11.00			11.00
	Light, heat and power	49.45			49.45			49.45
	Greenhouses	2,164.70			2,164.70		1,862.82	301.88
	Addition to smoke stack	165.50			165.50			165.50
	Printing warehouse	10,000.00			10,000.00			10,000.00
	Water wells	500.00			500.00			500.00
	Fencing	292.50			292.50		290.30	2.20
	Paving	2,185.37			2,185.37		2,181.07	4.30
	Reservoir	1,500.00			1,500.00			1,500.00
	Contributions	1,427.55			1,427.55			1,427.55
1918–19	Salaries	21,429.61			21.429.61			21.429.61
	Wages	11,358.92			11.358.92		888.37	10,470.55
	Wages unclassified	355.41			355.41		120.00	235.41
	Food supplies	22.00			22.00			22.00
	Forage supplies	9,215.20			9,215.20		3,508.63	5,706.57
	Fuel supplies	2,313.50			2,313.50		2,284.39	29.11
	Office supplies	129.24			129.24		127.78	1.46
	Cleaning supplies	125.43			125.43		15.62	109.81
	Agricultural supplies	449.52			449.52		69.80	379.72
	General plant supplies	7,889.40			7,889.40		3,347.27	4,542.13
	General plant materials	666.50			666.50		569.98	96.52
	Office equipment	99.27			99.27		97.80	1.47
	Livestock	1,500.00			1,500.00		250.00	1,250.00
	Wearing apparel	24.87			24.87		19.40	5.47
	Educational equipment	691.31			691.31		221.11	470.20
	General plant equipment	2,204.38			2,204.38		1,439.42	764.96
	Repairs	138.89			138.89		112.41	26.48
	Light, heat and power	350.00			350.00		12.49	337.51
	Transportation	6,274.72			6,274.72		1,226.98	5,047.74
	Transportation—Other	142.05			142.05		77.58	64.47
	Communication	5.29			5.29		1.31	3.98
	General plant service	40.89			40.89			40.89
	Rent	2,675.66			2.675.66		1,691.75	983.91
	Insurance	71.00			71.00			71.00

STATEMENT G
Balance Sheet, June 30, 1920—Concluded

Date of appropriation	Appropriation titles	Balance July 1, 1919	Appropriation	Receipts transfers	Total	Lapsed into State Treasury	Expenditures	Balance June 30, 1920
							†5,000.00	
1919-20	Salaries		128,360.00		128,360.00		117,592.16	5,767.84
	Wages		55,500.00	†5,000.00	60,500.00		56,427.31	4,072.69
	Wages—unclassified		200.00		200.00			200.00
	Food supplies		10.00		10.00			10.00
	Forage supplies		8,000.00		8,000.00		6,417.33	1,582.67
	Fuel supplies		7,000.00		7,000.00		4,764.82	2,235.18
	Office supplies		2,000.00		2,000.00		1,376.96	623.04
	Cleaning supplies		200.00		200.00		31.66	168.34
	Agricultural supplies		2,500.00		2,500.00		1,841.71	658.29
	General plant supplies		7,000.00		7,000.00		4,594.94	2,405.06
	Building materials		1,200.00		1,200.00		439.97	760.03
	General plant materials		3,000.00		3,000.00		1,767.20	1,232.80
	Office equipment		200.00		200.00		95.76	104.24
	Livestock		500.00		500.00			500.00
	Agricultural equipment		1,000.00		1,000.00		340.00	660.00
	Wearing apparel		15.00		15.00		2.25	12.75
	Educational equipment		700.00	†250.00	950.00		696.35	253.65
							†250.00	
	General plant equipment		8,000.00		8,000.00		4,614.78	3,135.22
	Repairs		2,000.00		2,000.00		1,793.86	206.14
	Light		200.00		200.00		197.81	2.19
	Freight, express and drayage		2,000.00		2,000.00		1,930.96	69.04
	Transportation		14,000.00		14,000.00		9,524.93	4,475.07
	Communication		500.00		500.00		462.13	37.87
	General plant service		1,200.00		1,200.00		573.29	626.71
	Land		28,100.00		28,100.00			28,100.00
	Boiler		3,000.00		3,000.00			3,000.00
	Fencing		1,000.00		1,000.00		395.13	604.87
	Rent		1,500.00		1,500.00		1,025.72	474.28
	Insurance		100.00		100.00		58 75	41.25
	Contributions		50.00		50.00		25.00	25.00
	Adams Fund		15,000.00		15,000.00		15,000.00	
	Hatch Fund		15,000.00		15,000.00		15,000.00	
	Adams Produce Fund	2,957.93		2,921.98	5,879.91		4,290.59	1,589.32
	Rotary Fund	7,810.37		34,197.58	42,007.95		36,009.41	5,998.54
	Produce Fund			19,555.19	19,555.19		19,555.19	
	Totals	$124,101.67	$309,035.00	$56,674.75 †5,250.00	$489,811.42 †5,250.00		$307,707.06 †5,250.00 *19,555.19	162,549.17

*Deposited in State Treasury to the credit of the General Revenue Fund. †Transfers.

APPENDIX

Monograph Bulletins

of the

Ohio Agricultural Experiment Station

for the year ended June 30, 1920

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INDEX

*Cf. Monthly Bulletin, Vol. IV, Nos. 7-12 and Vol. V, Nos. 1-6.

*Cf. Monthly Bulletin, Vol. IV, Nos. 7-12 and Vol. V, Nos. 1-6.